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Assessment of the Quality of the Saddang River as A Water Resource in North Toraja Regency Using Storet and Pollution Index

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Abstract

Background: The Saddang River in North Toraja Regency serves as a key water resource for domestic, agricultural, and fishery needs. Increased activity along the watershed may degrade water quality and threaten the sustainability of the river's functions.
Objective: This study aims to evaluate the water quality of the Saddang River as a water resource in North Toraja Regency using the STORET and Pollution Index methods.
Methods: Sampling was conducted at four observation points (upstream, two middle stations, and downstream) over two weeks, measuring temperature, pH, DO, BOD, COD, TDS, and Total Coliform, with reference to class II water quality standards in Government Regulation Number 22 of 2021.
Results: STORET classified the Saddang River as moderately polluted at all stations (scores: −11 to −15). The Pollution Index indicated more severe conditions: in Week 1, ST1 and ST4 were moderately polluted (IP 7.30–8.71) and ST2–ST3 were heavily polluted (IP 10.79–13.18); in Week 2, all stations were heavily polluted (IP 10.21–18.94). Dominant pollutants were Total Coliform, BOD, COD, and low DO (<4 mg/L), indicating organic and microbiological contamination from domestic sources. Water quality declined progressively from upstream to downstream.
Conclusion: Both STORET and Pollution Index methods confirmed water quality degradation in the Saddang River, with Total Coliform, BOD, COD, and low DO as dominant pollutants. ST2 and ST3 were identified as critical pollution hotspots requiring priority intervention. The combined application of both methods provides a robust framework for evidence-based water resource management in North Toraja Regency.

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INTRODUCTION

Rivers are water resources that play an important role in human life and the sustainability of aquatic ecosystems (Bănăduc et al., 2022). The increase in population, agricultural activities, industry, livestock operations, and the disposal of domestic and non-domestic waste without treatment has reduced the quality of river water (Muthaiyah, 2020). A decline in river water quality can have an impact on public health, a decrease in the productivity of the agricultural and fisheries sectors, and a disturbance in the balance of aquatic ecosystems (Simeonov et al., 2003). Therefore, regular monitoring and evaluation of river water quality are necessary as a basis for the formulation of water resource and environmental management policies. Such conditions are evident in the Saddang River, the main river in North Toraja Regency.

The Saddang River, which is a cross-provincial river in South Sulawesi and West Sulawesi Provinces, is the main river in North Toraja Regency used for various needs. In the National Regional Spatial Plan (RTRWN), North Toraja is a strategic area in South Sulawesi designated as a protected forest area; geographically, it is one of the districts with mountainous topography and dominant forest land use. This results in considerable water resource potential, making it possible to meet a range of water needs. Water quality refers to the degree of suitability of water for specific human uses, such as drinking water, irrigating plants, livestock watering, and so on (Meride & Ayenew, 2016).

Rivers, as part of the water resource system, play an important role in supporting human activities and environmental sustainability (Li et al., 2022). Along with the increase in anthropogenic activities in watersheds and changes in land use along the watershed, the potential for water quality decline is a problem that requires serious attention (Wang et al., 2023). River water quality is an important indicator in water resource management because it directly affects water utilization for domestic needs, irrigation, and water resource infrastructure planning, where water quality information is needed as the basis for planning raw water treatment, sedimentation control, and the sustainability of river hydraulic and ecological functions (Effendi, 2003; Sutadian et al., 2016).

Along with rapid population growth and increasingly advancing livelihoods, many water catchment areas are converted into residential areas and developed into urban, industrial, and commercial zones; in other words, changes in land use reflect the impact of human activities on the environment, causing water availability to decline and pollution to occur, affecting the water supply needed by communities.

One of the strategic water resources widely used for various development activities is river water. River water is a natural resource susceptible to receiving pollution loads from waste generated by human activities such as industrial activities, agriculture, trade, livestock, and households (Sharma et al., 2024). As a result of the decline in water quality, the quantity of water that meets quality standards has decreased. Considering that rivers are an important water resource for supporting economic development and human welfare, the function of rivers as a water resource must be preserved in order to support sustainable development (Hamuna et al., 2018). Water pollution is any contamination or addition of organisms or other substances to water such that it reaches a level that interferes with the use, utilization, and sustainability of the waters (Fitriana et al., 2025). The problem of water pollution is closely related to water quality.

Water quality data are needed in river management as the basis for determining the physicochemical characteristics of rivers. River water quality is inherently dynamic, changing over time due to seasonal variation, the type and amount of incoming waste, and streamflow discharge (Oyeboade & Olagoke-Komolafe, 2023).

Therefore, the evaluation of river water quality is an important part of planning and managing water resources. Previous research showed a decline in water quality due to livestock market activities around the river, with water quality status assessed using the Pollution Index method; the results indicated polluted conditions, thus emphasizing the need for routine monitoring (Tarru et al., 2022). In the present study, water quality status assessment was conducted using two methods: the STORET (STOrage and RETrieval) method and the Pollution Index (PI), as stipulated in the Decree of the Minister of Environment Number 115 of 2003.

The STORET and PI methods represent two widely applied approaches for assessing river water quality, yet prior studies generally employ them independently, often producing differing classifications due to methodological distinctions. STORET evaluates cumulative deviations from regulatory quality standards through a weighted scoring system, whereas the PI method generates an aggregated numerical index based on parameter ratios relative to permissible limits.

Despite their frequent application in Indonesia, limited studies have critically compared both methods within the same temporal and spatial framework, particularly in the Saddang River basin. Consequently, the extent to which methodological differences influence pollution status interpretation in this watershed remains insufficiently examined. This study addresses that gap by conducting a simultaneous and systematic application of STORET and PI to identify potential discrepancies, evaluate their sensitivity to dominant pollutants, and provide a more robust and comprehensive assessment framework for evidence-based water quality management.

Furthermore, no previous study has conducted a simultaneous comparative assessment of both STORET and PI methods within the Saddang River basin in North Toraja Regency, leaving a critical knowledge gap regarding the methodological consistency and interpretive reliability of these approaches in a cross-provincial watershed context. This study directly addresses that gap.

Research on the water quality of the Saddang River is particularly important given its role as a strategic water resource in North Toraja Regency. Information on water quality status can serve as the basis for formulating policies on water resource management, pollution control, and environmentally sound development planning. In addition, the results of this research can also raise public awareness about the importance of maintaining river water quality.

Based on the foregoing, the assessment of Saddang River water quality using the STORET method and the Pollution Index is a relevant and strategic step. This study aims to provide a scientific picture of the actual condition of water quality in the Saddang River, identify the level of pollution that occurs, and recommend sustainable management measures to maintain the function of the river as the main water resource in North Toraja Regency.

LITERATURE REVIEW

STORET Method

In the Decree of the Minister of Environment No. 115 of 2003 concerning Guidelines for Determining Water Quality Status, there are two methods that are often used to determine water quality status, namely the STORET method and the PI (Pollution Index) method; both methods were developed in the USA. The STORET method is one of the commonly used methods to determine the status of water quality. With this STORET method, the parameters that have met or exceeded the water quality standards can be identified.

In principle, the STORET method compares water quality data with water quality standards that are adjusted to their intended purpose to determine water quality status. The way to determine water quality status is to use the US EPA (Environmental Protection Agency) rating system by classifying water quality into four classes, namely: (1) Class A: very good, score = 0, meets quality standards; (2) Class B: good, score = −1 to −10, light pollution category; (3) Class C: medium, score = −11 to −30, medium pollution category; and (4) Class D: poor, score ≤ −31, heavy pollution category.

The STORET method has the advantage of being able to conclude the status of water quality within a certain time frame, making it easy to understand for the general public. This method is effectively used in flowing waters such as rivers. The disadvantage of this method is that it requires several series of sufficient data in determining river water quality, which necessitates a relatively larger cost and a longer time. Fermana (2025) explained that tropical rivers in Indonesia are best assessed using water quality indices such as PI, STORET, and CCME, all of which have flexibility in the number and type of water quality parameters used to determine water quality status.

However, this flexibility can create inconsistencies in the use of water quality parameters that are important for determining the water quality index in a river (Wu et al., 2018). The number and types of important water quality parameters that need to be used in the calculation of the Water Quality Index for tropical rivers in Indonesia in general need to be studied further so that they can explain the dynamics of water quality and pollution problems that occur. The accumulation of negative scores is used to determine the status of water quality, ranging from meeting quality standards to being heavily polluted. The STORET method is known to have high sensitivity to violations of quality standards because each parameter is evaluated individually (Fitriana et al., 2025; Mufida & Rachmanto, 2023).

Pollution Index Method

The Pollution Index (PI) is an aggregate water quality assessment approach that quantifies pollution status by calculating the ratio between measured parameter concentrations and corresponding regulatory quality standards (Hossain & Patra, 2020; Khan et al., 2023). The resulting index value represents the overall degree of contamination within a water body. Unlike violation-based scoring systems, the PI method integrates both maximum and average parameter values, making it sensitive to dominant pollutants while still reflecting cumulative conditions (Fauzi et al., 2025). Water quality classification in this study refers to the applicable national water quality standards to ensure regulatory consistency and relevance.

Although the PI method has been widely applied in river assessments, most previous studies have employed it as a single-method evaluation without systematically comparing its results with other assessment frameworks within the same spatial and temporal context. Consequently, limited evidence exists regarding how methodological differences influence pollution status interpretation, particularly in regional watersheds.

This study addresses that gap by applying the Pollution Index concurrently with the STORET method to evaluate differences in sensitivity, classification outcomes, and policy implications. The research objective is to determine the comparative performance of both methods in assessing river water quality and to identify the dominant parameters influencing pollution status, thereby supporting more robust and evidence-based water resource management decisions.

Based on the foregoing, this study is motivated by three interrelated research gaps: (1) the absence of a comparative multi-method assessment (STORET and PI concurrently) in the Saddang River basin; (2) the lack of spatiotemporal analysis of pollution intensity across upstream-to-downstream transects in North Toraja; and (3) insufficient evidence linking dominant pollutant parameters to land-use patterns in this watershed. The specific objectives of this study are: (a) to determine the water quality status of the Saddang River using STORET and Pollution Index methods simultaneously; (b) to identify the dominant parameters contributing to pollution; and (c) to compare the sensitivity and classification outcomes of both methods to support evidence-based water resource management decisions.

Table 1. Evaluation of the Pollution Index (IP) value

Water Quality Index	Remarks
0IP1.0 $< \leq$	Meet quality standards (good condition)
1.0IP 5.0 $< <$	Light pollution (*slightly polluted*);
5.0 IP 10$< \leq$	Moderate pollution (*moderately polluted*)
IP10 $>$	Heavy pollution (*heavily polluted*).

Source: Decree of the Minister of State for the Environment No. 115 of 2003

Determination of Pollution Index

$$IP = \text{...}(1)\sqrt{\frac{(C_i/L_{ij})^2M + (C_i/L_{ij})^2R}{2}}$$

Where:

- Lij : The concentration of water quality parameters listed in the Quality Standards for a Water Designation (j),
- Ci : The concentration of water quality parameter (*i*) obtained from the analysis of water samples collected at a sampling location along the river channel, and the results of the measurement
- PIj : Pollution Index for provision (j), which is a function of C*i*/L*ij*.

Several studies have shown that the use of both methods simultaneously can provide a more comprehensive and relevant water quality evaluation for water resources management planning (Akhtar et al., 2021; Mufida & Rachmanto, 2023).

METHOD

Table 2. Geographic Coordinates of Sampling Stations

Station	Latitude (S)	Longitude (E)	Segment	Dominant Land Use
ST1	3°02'14.2"S	119°54'08.1"E	Upstream	Protected forest/agriculture
ST2	3°04'32.7"S	119°55'41.3"E	Midstream	Settlements/domestic activities
ST3	3°06'18.9"S	119°56'54.6"E	Midstream-down	Mixed settlement/ runoff
ST4	3°08'45.1"S	119°58'12.4"E	Downstream	Agricultural/lower settlement

Research Location

The research was conducted in the Saddang River, North Toraja Regency, South Sulawesi. Sampling was carried out at four observation points representing the upstream, middle, and downstream parts of the river, over two consecutive weeks. The data used are in the form of primary data obtained through water sampling at the four points, which represent the upstream, middle, and downstream areas of the river. All water samples were analyzed at the Public Health Laboratory (Labkesmas Makassar I) for the following parameters: temperature, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, and total coliform. The measurement data refer to Class II water quality standards in accordance with Government Regulation Number 22 of 2021 to determine the water quality status of the Saddang River.

Study Area and Sampling Design

The study was conducted in the Saddang River, North Toraja Regency, South Sulawesi, Indonesia. Four monitoring stations (ST1–ST4) were purposively selected to represent upstream, midstream, and downstream segments based on land-use characteristics and potential anthropogenic pressures. Geographic coordinates of each station were recorded using a GPS to ensure spatial accuracy.

Sampling was conducted over two consecutive weeks to capture short-term variability under comparable hydrological conditions. Although limited in duration, the monitoring period was designed to represent baseline dry-season conditions and minimize rainfall-induced fluctuations. Future longitudinal monitoring is recommended to capture seasonal variability.

Sampling Procedure and Laboratory Analysis

Water samples were collected using grab sampling techniques at approximately 30–50 cm below the surface. Sampling was conducted in the morning (08:00–11:00) to reduce diurnal variation effects. Samples were preserved in sterile polyethylene bottles and stored in cooled containers (4°C) during transport.

Laboratory analyses were performed at Labkesmas Makassar I following APHA (2017) and relevant Indonesian National Standards (SNI). Parameters analyzed included temperature, pH, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), and Total Coliform.

Data Analysis

Water quality status was evaluated against Class II standards under Government Regulation No. 22/2021. The STORET score was calculated using cumulative penalty scoring for each parameter exceeding regulatory limits:

$$STORET = \sum(negative\ deviation\ \text{scores})$$

The Pollution Index (PI) was calculated as:

$$PI = \sqrt{\frac{2(Ci/Li)max2+(Ci/Li)avg2}{2}}$$

where CiC_iCi represents measured concentration and LiL_iLi the corresponding standard.

Descriptive statistical analyses (mean, maximum, minimum) were applied prior to index calculation. Quality assurance/quality control (QA/QC) procedures included instrument calibration, blank samples, duplicate analysis, and standard reference comparison to ensure analytical reliability.

Table 2. Quality Standards of Government Regulation Number 22 of 2021

No.	Parameter Type	Units	Maximum Allowable Rate
	Microbiological Parameters		
1	Total Coliform	100 ml/sample	5000
	Physics Parameters		
2	a. Total Solid Stamina (TDS)	Mg/l	1000
	b. Temperature	^{0}C	Air temperature ±3^{0}C
	Chemical Parameters		
3	a. DO	Mg/l	≥ 4
	b. BOD	Mg/l	≤ 3
	c. COD	Mg/l	≤ 25
	d. pH	Mg/l	6,5-9

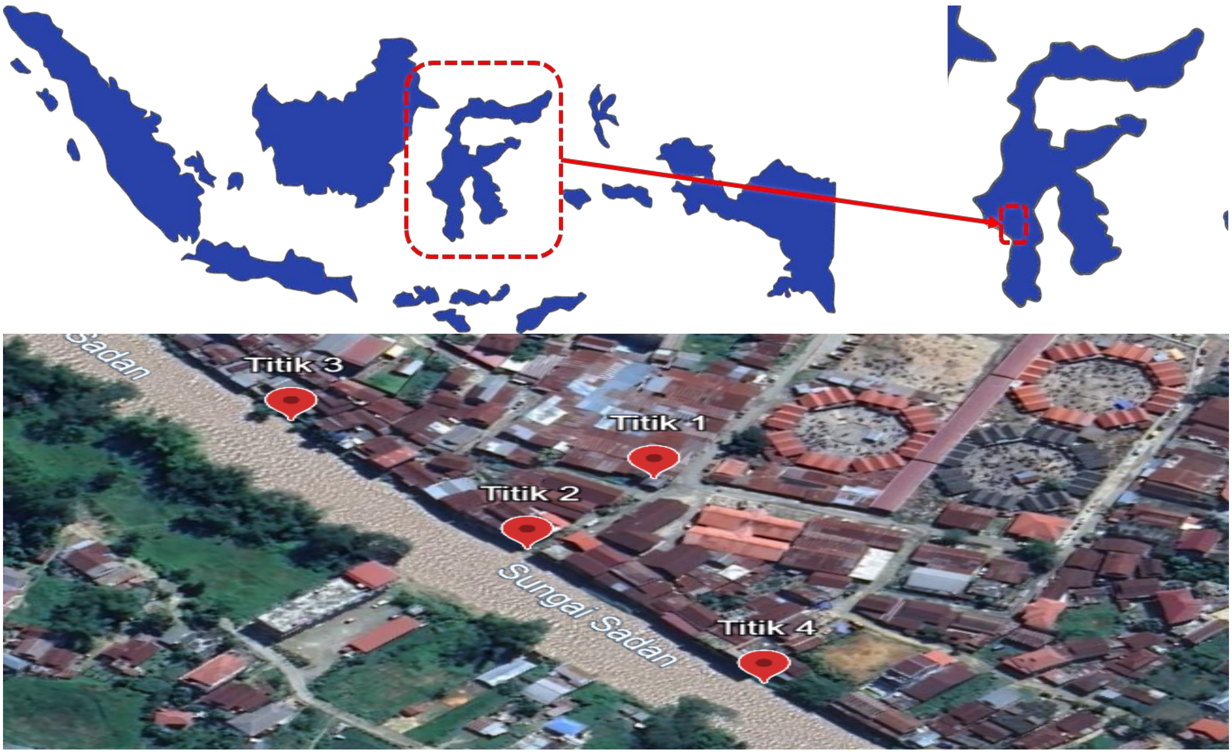

Figure 1. Research Location

RESULTS AND DISCUSSION

Results

The results are presented in four subsections: (3.1) water quality measurements, (3.2) STORET-based assessment, (3.3) Pollution Index assessment, and (3.4) comparative analysis and management implications. Each subsection includes analytical interpretation supported by comparison with relevant literature and regulatory standards (Government Regulation No. 22/2021). Statistical data are reported as mean ± range across stations and weeks.

Results of water quality measurements of the Saddang River

Table 3. Results of Water Quality Measurement of the Saddang River in the First Week

Stations	Temperature (°C)	TDS (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	pH	Total Coliform (MPN/100 mL)
1	27.3	110.1	6.81	7.30	18.64	6.62	290,900
2	27.2	994.9	0.06	265.82	652.76	6.98	10,170,000,000
3	27.2	248.4	0.31	31.70	79.23	6.55	2,603,000
4	27.0	116.8	6.19	9.41	23.41	6.66	717,000

Table 4. Results of Water Quality Measurement of the Saddang River in the Second Week

Stations	Temperature (°C)	TDS (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	pH	Total Coliform (MPN/100 mL)
1	28.5	148.3	6.91	27.20	68.93	6.38	2,613,000
2	28.4	374.4	6.53	454.29	1,134.66	6.71	410,000,000
3	28.6	160.5	5.75	56.00	133.69	6.38	3,654,000
4	28.2	150.8	7.14	45.82	112.83	6.80	1,664,000

Water Quality Status of the STORET Method

Table 5. STORET Assessment Results in the First Week

Parameters	Units	ST1	ST2	ST3	ST4
Temperature	^{0}C	-1	-1	-1	-1
Total Dispended Solids (TDS)	Ppm	0	-2	0	0
Dissolved Oxygen (DO)	Ppm	-2	-2	-2	-2
Biochemical Oxygen Demand (BOD)	Ppm	-2	-2	-2	-2
Chemical Oxygen Demand (COD)	Ppm	-2	-2	-2	-2
Degree of acidity (pH)		0	0	0	0
Total Coliform	colony/100ml	-6	-6	-6	-6
		-13	-15	-13	-13

Table 6. Water Quality Status Category Based on STORET First Week

Dot	STORET Value	Water Quality Category
ST1	-13	Moderately Polluted
ST2	-15	Moderately Polluted
ST3	-13	Moderately Polluted
ST4	-13	Moderately Polluted

Table 7. STORET Assessment Results in the second week

Parameters	Units	ST1	ST2	ST3	ST4
Temperature	^{0}C	-1	-1	-1	-1
Total Dispended Solids (TDS)	Ppm	0	-1	0	0
Dissolved Oxygen (DO)	Ppm	-2	0	0	-2
Biochemical Oxygen Demand (BOD)	Ppm	-2	-2	-2	-2
Chemical Oxygen Demand (COD)	Ppm	-2	-2	-2	0
Degree of acidity (pH)		0	0	0	0
Total Coliform	colony/100ml	-6	-6	-6	-6
		-13	-12	-11	-11

Table 8. Category Water Quality Status Based on STORET Week Two

Dot	STORET Value	Water Quality Category
ST1	-13	Moderately Polluted
ST2	-12	Moderately Polluted
ST3	-11	Moderately Polluted
ST4	-11	Moderately Polluted

STORET-based scores ranged from −11 to −15 across ST1–ST4 during both monitoring weeks, classifying the Saddang River as moderately polluted at all stations. Although classification categories were uniform, spatial intensity differences were evident. ST2 consistently recorded the lowest score (−15 in Week 1; −12 in Week 2), indicating relatively higher pollution pressure compared to other stations.

The dominant contributors to negative scores were Total Coliform (−6 at all stations), BOD, COD, and low DO (−2), confirming that organic and microbiological contamination is the principal stressor. In contrast, pH remained within standards, suggesting that acid–base balance is not a controlling pollution factor. The persistent oxygen depletion reflects high organic loading and active microbial decomposition.

Spatially, pollution severity increased from upstream (ST1) toward midstream (ST2–ST3), then slightly improved downstream (ST4), suggesting cumulative anthropogenic inputs. The critical condition at ST2 is likely associated with higher settlement density, domestic wastewater discharge, and runoff contributions, indicating a predominantly point-source influence amplified by localized land-use intensity.

However, the uniform STORET classification masks variability magnitude because the method applies fixed violation weights rather than proportional scaling. This explains why extreme parameter values at ST2 did not shift category status.

Statistical validation was limited to descriptive comparisons due to the short two-week monitoring period, which may not fully represent temporal variability or seasonal hydrological dynamics (dry vs. rainy season). Future studies should incorporate longer-term datasets, land-use correlation analysis, and uncertainty estimation to strengthen inference reliability.

Overall, while STORET confirms moderate pollution status, parameter dominance and spatial clustering highlight ST2–ST3 as priority zones for targeted pollution control and watershed-based management interventions.

A comparative analysis of STORET and PI results reveals methodological differences in sensitivity and classification. STORET categorized all stations as moderately polluted in both weeks (uniform category), whereas PI differentiated stations more distinctly (ST2–ST3 as heavily polluted in Week 1; all stations as heavily polluted in Week 2). This divergence reflects the inherent design of each method: STORET applies fixed violation scores, capping sensitivity to extreme values, whereas PI uses proportional concentration ratios that amplify the contribution of severely exceeded parameters. These findings are consistent with Mufida (2023) and Yuda Romdania (2018), who noted that PI tends to indicate more critical conditions under high organic loading compared to STORET.

Table 9. Comparative Summary: STORET vs. Pollution Index Classification

Station	STORET W1	Category	STORET W2	Category	PI W1	PI W2	Most Critical
ST1	-13	Moderate	-13	Moderate	7.30	10.84	Moderate→Heavy
ST2	-15	Moderate	-12	Moderate	13.18	18.94	Heavy (both)
ST3	-13	Moderate	-11	Moderate	10.79	11.41	Heavy (both)
ST4	-13	Moderate	-11	Moderate	8.71	10.21	Moderate→Heavy

Water Quality Status of the Pollution Index Method

Table 10. Pollution Index in the First Week

No.	Parameters	Units	Ci/Lij New			
			ST1	ST2	ST3	ST4
1	Total Coliform	5000	9,82	17,54	14,58	11,78
2	Temperature	±3^{0}C	5,80	5,79	5,79	5,77
3	Total Solid Stamina (TDS)	300	0,11	0,99	0,25	0,12
4	DO	≥ 4	2,16	0,02	0,08	2,19
5	BOD	≤ 3	2,93	10,74	6,12	3,48
6	COD	≤ 25	0,36	8,08	3,50	0,94
7	pH	6,5-9	1,02	1,07	1,01	0,74
Quantity			22,20	44,23	31,33	25,02
Average score			3,17	6,32	4,48	3,57
Maximum value			9,82	17,54	14,58	11,78
IP			7,30	13,18	10,79	8,71

Table 11. Water Quality Status Categories Based on Pollution Index

Dot	IP Value	Water Quality Category
ST1	7,30	Moderately Polluted
ST2	13,18	Heavily Polluted
ST3	10,79	Heavily Polluted
ST4	8,71	Moderately Polluted

Table 12. Pollution Index in the second week

No.	Parameters	Units	Ci/Lij New			
			ST1	ST2	ST3	ST4
1	Total Coliform	5000	14,59	25,57	15,31	13,61
2	Temperature	±3^{0}C	5,89	5,88	5,59	5,87
3	Total Solid Stamina (TDS)	300	0,15	0,3744	0,1605	0,1508
4	DO	≥ 4	2,19	2,06	1,79	2,26
5	BOD	≤ 3	5,79	11,90	7,36	6,92
6	COD	≤ 25	3,20	9,28	4,64	4,27
7	pH	6,5-9	0,98	0,745556	0,7506	0,8
Quantity			32,79	55,82	35,60	33,88
Average score			4,68	7,97	5,09	4,84
Maximum value			14,59	25,57	15,31	13,61
IP			10,84	18,94	11,41	10,21

Table 13. Water Quality Status Categories Based on Pollution Index

Dot	IP Value	Water Quality Category
ST1	10,84	Heavily polluted
ST2	18,94	Heavily polluted
ST3	11,41	Heavily polluted
ST4	10,21	Heavily polluted

Based on Table 9 and Table 11, the Pollution Index (IP) values for the four observation stations (ST1–ST4) during the first and second weeks were obtained as 7.30, 13.18, 10.79, and 8.71, respectively. Referring to the criteria for determining water quality status, an IP value of 5–10 is categorized as moderately polluted, while an IP value of >10 falls within the heavily polluted category. Thus, ST1 and ST4 are classified as moderately polluted, while ST2 and ST3 are classified as heavily polluted. The highest IP value was found at ST2 (13.18), which indicates the worst water quality conditions compared to the other stations. The high IP value at this station is mainly influenced by Total Coliform (17.54), BOD (10.74), COD (8.08), and very low DO values (0.02).

High total coliform concentrations indicate domestic waste contamination. Meanwhile, high BOD and COD indicate elevated levels of organic matter in the water. This condition correlates with low DO, as dissolved oxygen is consumed by microorganisms to decompose organic matter, thus causing an oxygen deficit in the water. At ST3 (IP = 10.79), the condition of the water was also classified as heavily polluted.

The dominant parameters affecting the high IP were Total Coliform (14.58) and BOD (6.12), accompanied by very low DO (0.08). This pattern exhibits similar organic pollution characteristics to ST2, albeit with lower intensity. Low DO in ST2 and ST3 has the potential to disrupt the balance of aquatic ecosystems and threaten the sustainability of aquatic biota. Meanwhile, ST1 (IP = 7.30) and ST4 (IP = 8.71) fall within the moderately polluted category. At these two stations, the Total Coliform value remained the dominant parameter, at 9.82 and 11.78, respectively.

The DO values at both stations (2.16 and 2.19) were still below the quality standard (≥4 mg/L), which indicates that the water has not been able to optimally support aquatic life. However, the BOD and COD values are relatively lower than those at ST2 and ST3, so the pollution level is not as severe as at those two stations. The study site is dominated by organic and microbiological pollution, which generally originates from domestic activities, residential runoff, and other human activity waste. These results show significant pollution of water bodies, particularly at ST2 and ST3. The results of the Pollution Index (IP) measurements in the second week showed that all monitoring stations were in the heavily polluted category, with the highest IP value recorded at ST2 at 18.94.

The parameters that contribute most to this pollution are Total Coliform, BOD, COD, and low levels of DO. High total coliform at all stations indicates biological contamination due to domestic waste. This is because settlement activities and the direct disposal of domestic waste into water bodies are the main sources of pollution. In addition, high BOD and COD values indicate excessive concentrations of organic matter, which leads to a decrease in dissolved oxygen (DO) levels. Low DO conditions at all stations (below the quality standard of ≥4 mg/L) have the potential to cause oxygen depletion in aquatic organisms and reduce the carrying capacity of aquatic ecosystems. ST2 and ST3 show the most critical conditions with the highest IP values and are therefore top priorities in water quality management, while ST1 and ST4 still require intervention so that water quality conditions can be improved.

Discussion

Comparative Analysis and Management Implications

The discrepancy between STORET and PI classifications reflects their distinct computational logics. STORET assigns fixed penalty scores to parameter violations (−1 for physical parameters, −2 for chemical parameters, and −3 for biological parameters when exceeded), which creates uniform category thresholds regardless of violation magnitude. In contrast, PI calculates the ratio Ci/Li for each parameter, making it proportionally sensitive to the degree of exceedance. Consequently, extreme concentrations—such as Total Coliform values exceeding 10,000,000 MPN/100 mL at ST2 in Week 1—disproportionately influence the PI score but contribute only a fixed −6 to the STORET total. This explains why PI classified ST2 as heavily polluted (IP = 13.18) while STORET categorized it only as moderately polluted (−15). Similar methodological divergence patterns have been documented by Mufida (2023) and Fauzi (2025) in Indonesian river systems.

From a management perspective, the combined application of both methods offers complementary insights: STORET provides a straightforward categorical assessment suitable for regulatory reporting and public communication, while PI offers finer-grained discrimination between pollution levels and highlights hotspot stations. ST2 and ST3 are consistently identified as priority zones by both methods, indicating the need for targeted point-source pollution control. Recommended interventions include: (1) construction of communal wastewater treatment facilities near ST2; (2) enforcement of riverbank waste disposal regulations; (3) implementation of riparian buffer zones along midstream segments; and (4) establishment of a continuous water quality monitoring network with seasonal coverage to capture dry-season versus wet-season variability that the current two-week monitoring period could not adequately characterize (Akhtar et al., 2021; Fauzi et al., 2025).

CONCLUSION

This study assessed the water quality of the Saddang River, North Toraja Regency, using STORET and Pollution Index (PI) methods across two monitoring weeks at four stations (ST1–ST4). STORET classified all stations as moderately polluted (scores: −11 to −15), while PI revealed more critical conditions, with ST2–ST3 classified as heavily polluted in Week 1 (IP: 10.79–13.18) and all stations as heavily polluted in Week 2 (IP: 10.21–18.94). Total Coliform, BOD, COD, and low DO were consistently the dominant pollutants, reflecting organic and microbiological contamination predominantly from domestic sources. ST2 was the most critical station in both methods and monitoring periods. The combined use of STORET and PI provides a more comprehensive evaluation framework, with PI being more sensitive to extreme pollutant concentrations. Priority interventions include domestic wastewater management at ST2–ST3, stricter watershed supervision, and long-term monitoring programs.

It is recommended to prioritize the construction of communal and household wastewater treatment plants (WWTPs) around Stations 2 and 3 to reduce domestic and non-domestic waste inputs, alongside increasing natural or artificial aeration to improve dissolved oxygen (DO) levels and aquatic habitat quality. Regular water quality monitoring should be strengthened and integrated with community-based environmental education programs to enhance public awareness and participation. Furthermore, the Regional Government needs to enforce stricter supervision and legal control over domestic, commercial, and industrial waste disposal, complemented by continuous environmental awareness campaigns to foster collective responsibility for sustainable river management.

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AUTHOR CONTRIBUTION STATEMENT

Reni Oktaviani Tarru contributed to the conceptualization of the study, data collection, analysis of the results, and the writing of the manuscript. She was responsible for the coordination of the research process and the integration of both the STORET method and Pollution Index method for water quality assessment. Juliah Sarira contributed to the design of the research methodology, providing guidance on the interpretation of data, and offering substantial revisions to the manuscript. Marianne Y Marrung was involved in the literature review and provided valuable suggestions regarding the theoretical framework. Harni Eirene Tarru and Yulius Pakiding provided additional support in data collection and analysis, contributing to the refinement of the final manuscript.

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